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The Effect Of Gender, Confirmation Bias, And Metacognitive Self Assessment Over Varying Levels Of Expertise In A Visuospatial Task

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THE EFFECT OF GENDER, CONFIRMATION BIAS, AND METACOGNITIVE SELF ASSESSMENT OVER VARYING LEVELS OF EXPERTISE IN A VISUOSPATIAL TASK

by

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ABSTRACT

It has been shown that there exists a relationship between levels of metacognitive ability and estimation of personal ability for largely verbally-based tasks, where those with lessened facility for the task tend toward overestimation of their aptitude relative to their peers (Kruger and Dunning, 1999). This study examines this effect for a task of mechanical ability for volunteer participants (n = 69), where participants were given an abbreviated form of the Bennett Mechanical Comprehension Test (BMCT) to establish a level of competency. Following the administration of the BMCT, the participants were then asked to speculate on the hypothetical grade for their performance, as well as the relationship between their hypothetical grade, and the grades of others. Participants then "tutored" a hypothetical student on the solution to one of the problems found on the BMCT, and their explanations were coded for degree of bias towards confirmation versus disconfirmation that was utilized in the problem solving. It was found that females' basic ability had a greater range than males', and females on the high and low ends of competency made greater use of confirming strategies in their problem solving. This is indicative of the overall observed interaction effect between Gender, Perceived Relative Competence, and Actual Competence observed in this study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS/ABBREVIATIONS

BMCT	Bennett Mechanical Comprehension Test

CHAPTER ONE: INTRODUCTION

Previous research has shown that in a variety of domains, unskilled participants are less able to accurately use metacognitive processes to pinpoint their ability relative to others (Kruger and Dunning, 1999). Prior studies have examined the interactions of many different factors in establishing that there exists a difference in performance between novice and expert. It is implied that for many tasks where metacognitive capacity is lacking, there will also be a deficit in actual ability for that task. The individual then continues to exhibit low competence as a result of a "double-insult"—they are unable to receive effective feedback on their poor performance because they lack the metacognition to arrive at the determination that the performance is poor in the first place. This appears to often translate into an overestimation of their own ability, and concomitant underestimation of the ability of others. Although this finding is well documented in fields requiring a great deal of verbal ability (Dawson, Gilovich, and Regan, 2002; Kruger and Dunning, 1999; Slugoski and Wilson, 1998), it has not been demonstrated using a highly spatial task.

Mechanical ability is being defined in accordance with the Bennett Mechanical Comprehension Test. Essentially, it is demonstrated skill at identifying interrelationships between items, given commonly accepted physical laws. For example, Pulley A causing Pulley B to rise or lower depending upon how the pulleys are connected and manipulated. Mechanical problems have been selected as the task material for several beneficial reasons: First, mechanical problems are an accepted benchmark by which one may be said to clearly possess or lack a level of proficiency. Second, it was assumed that there is no stereotypical stigma associated with the

demonstration of, or failure to demonstrate, mechanical ability. For this reason, it was anticipated that few participants if any would have preconceived ideas of themselves as "not mechanically able" people, whereas it would be more expected to encounter participants who already considered themselves to be "not a math person"; because of the absence of a broadly popular stereotype of the "not mechanically able" person, it was felt that participants were less likely to be affected by or self-conscious of, not "getting" a particular mechanical ability-based problem. Third, mechanical problems are not directly perceived as being "hard", threatening, or "math-like", even though mechanical ability can be likened to mathematical ability to a certain extent. Fourth, mechanical ability and/or talent may be learned or relatively innate, and therefore the proficient sample of participants was expected to be from various backgrounds, and in this way more representative of a larger population.

Confirmation bias is the predisposition to attend to supporting examples of currently-held beliefs while ignoring or minimizing disconfirming evidence. An individual's perceived level of competence or expertise is a personal, informal estimation of one's own performance or abilities, usually relative to one's peers. An individual may have low ability in practice, and an inflated assessment of performance, yet employ confirmation bias-type approaches to problem solving and be unaware that they employ a strategically different approach in one of their high-ability, low perceived expertise areas.

Confirmation bias has previously been studied as it relates to judgement, hypothesis testing, and problem solving; research has examined several different aspects of the inclination towards confirmation or disconfirmation, such as social, rule-based, agreeableness of proposition, or level

of familiarity, however little has been done to examine the relationship between level of expertise and the tendency to seek and process disconfirmatory evidence, particularly with respect to an individual's perceived level of expertise. These factors have not been adequately studied in tandem to attempt to observe a relationship, and a demonstrated relationship would be of benefit to the study of cognition, as well as application of learning theory.

For this reason, the purpose of this study was to investigate the interaction between level of expertise, perceived level of expertise, and the degree to which confirmation bias is employed or abandoned as a problem-solving strategy. Specifically, it was felt that this would be accomplished by identifying and measuring comments made during a natural-environment style tutoring session. It was believed that this would allow the strategy participants advise a "lesser-skilled" peer to adopt in approaching mechanically-based problems (and the inclination to confirm or disconfirm) to be measured.

Based upon previous research (Kruger and Dunning, 1999), two hypotheses were investigated: First that, as a whole, higher-skilled participants would tend toward underestimation of their performance, and lesser-skilled participants would tend toward overestimation of their performance, and the miscalibration of the lesser-skilled participants would far surpass the relative underestimation of the higher-skilled participants. Second, that lesser-skilled participants would demonstrate a greater reliance on confirming strategies in their explanation of a selected problem during a mock tutoring session relative to the higher-skilled participants; these higher-skilled participants were anticipated to employ a greater degree of disconfirmation strategy relative to the lesser-skilled group, if not overall.

It would be expected that, for a visuospatial task, the phenomenon of low competence resulting in an overestimation of personal ability and underestimation of an "acceptable" performance baseline would be noticeable. Considering that visuospatial tasks of mechanical ability often require a form of problem solving that, while differing from verbal tasks, is similar in nature to mathematical problem solving in that there are initial conditions which must be assumed and tested, it was felt that the degree to which an expert or novice makes use of confirmation bias might be reflective of a larger approach to problem solving in a visuospatial realm. It is also indicated by previous studies that this approach will differ between experts and novices; previous studies have demonstrated that problems based upon well-known physical laws are not themselves inherently understood (McCloskey and Kohl, 1983; Hecht and Bertamini, 2000), and for this reason could be thought to be participant to similar errors in reasoning as verbally-based tasks. Additionally, it may be argued that there is, in fact, greater bias to consider mechanical/physical problems as inherently-known or easily understood as evinced by the fact that there are few studies assessing the accuracy of naïve theories of acquiring language that do not acknowledge the confounding factors of development and training. Anecdotally, there seems to be a predisposition to assume that physics/mechanical ability/mathematics/engineering utilizes a more "common sense" approach than many verbally-based participants, where the need for memorization of rules and rehearsal of unfamiliar principles appears to be recognized.

Given that science, mathematics, and engineering classes are often considered challenging by undergraduates as well as the general populace, this domain is important to examine in that self-enhancement, or overestimation of one's ability, in combination with decreased capacity of

metacognition, may account for under-preparedness leading to lowered comprehension and performance, and a resultant assessment of the participant matter as “difficult”. The purpose of the present study was to investigate metacognitive ratings of participants’ own relative ability in a visuospatial domain—mechanical ability, and assess the degree to which participants make use of confirmation bias in their problem solving efforts.

CHAPTER TWO: LITERATURE REVIEW

Anecdotally, instances of overestimation of one's abilities abound—whether these anecdotes are personal experiences, or vicarious observations. Similarly, in trying to come up with instances of underestimation of ability, one usually has many convenient examples at the ready. Such is the nature of the estimation of one's own ability, the review of one's performance, and the nature of biographical information in general; this information is contained in narrative or largely anecdotal format, and is metacognitively scanned for relevance prior to actual retrieval. Evidence indicates that, on average, individuals tend to hold overly favorable views of their abilities and talents across many different domains. As a result, often an individual's estimated performance differs, at times significantly, from their actual ability at a given task; from personal experience it can be seen that it is highly likely that one's anticipated performance will differ from actuality, especially if one is looking at the estimation and performance of another. Why do so many people tend to think that they will perform better than they do, and why is it so difficult for them to see this discrepancy?

Explanations offered for the difference between actual and estimated performance that favor the individual doing the estimating typically call upon the phenomenon known as the "above-average effect", "better-than-average effect", or "Lake Wobegon Effect" (Harrison and Shaffer, 1994; Kruger, 1999; Krueger and Mueller, 2002, Dunning, Johnson, Ehrlinger, and Kruger, 2003). This above-average effect is the tendency for an individual to anchor their estimate of their own performance, ability, talent, or trait as being greater than the performance, ability,

talent, or traits of others with regard to neutral/ambiguous or positive/socially desirable characteristics (Nier, 2004; Kudo, 2004). Manifestations of the above-average effect are highly visible, particularly with regard to social skills, ability, or achievements. For example, Harrison and Shaffer (1994) demonstrated that a full 85 – 95% of their participants felt themselves to be above-average in workplace absenteeism, a measurement that would seem at first to be fairly immune to misinterpretation, in that one is either absent from work or one is present at work, a binary option that leaves little room for creative interpretation. This is a most significant effect, but is echoed if not equalled in other studies. As Kruger (1999, p. 221) details, such above-average estimates are observable "…not only in individualist cultures such as Canada, France, the Netherlands, Australia, and the United States, but also in collectivist cultures such as Japan and China, where modesty is purportedly praised". As observed in an empirical setting, humans tend to think of themselves as "more athletic, intelligent, organized, ethical, logical, interesting, fair-minded, and healthy—not to mention more attractive—than the average person" (Kruger, 1999). Despite the availability of automobile accidents reported in the daily news and traffic reports to aid us in our computations, we also consider our driving skills to be above-average (Svenson, 1981, qtd. Gilovich, 1991), along with many other reason-improbable or statistically unlikely activities; the rules, it seems in many cases of ability, just simply don't apply to *us*.

In addition to estimating one's abilities as above-average, another manifestation of the above-average effect is the individual's perseveration of belief that they are less likely to experience many (or all) of life's negative events, also called *comparative-optimism*, or *unrealistic-optimism effect* (Chambers, Windschitl, & Suls, 2003; Chambers and Windschitl, 2004; Klar and Ayal, 2004). For example, comparatively similar events that differ only in degree of desirability (e.g.,

having someone hold the door open for you versus getting into an auto accident) (Chambers, Windschitl, & Suls, 2003), individuals are significantly more likely to believe that it is more probable that they will experience positive life events than negative ones. This holds true for all manner of positive and negative events, from becoming wealthy to having a limb amputated; finding money on the ground to becoming a victim of crime (Chambers, Windschitl, & Suls, 2003; Klar and Ayal, 2004).

Estimation of one's own ability as above-average, although mathematically improbable (given that everyone else is likely to be rating themselves as equally above-average), appears to come about as an attempt to bolster one's self concept (Alicke 1985; Gilovich, 1991; Kruger, 1999; Chambers and Windschitl, 2004; Nier, 2004). Individuals also rate their friends' personal attributes as above-average in comparison to a general population, though not as much above-average as their own (Suls, Lemos, and Stewart, 2002). In part, this misestimation of one's abilities and propensities may be related to a form of fundamental attribution error, or actor/observer bias—the attention paid to one's internal thoughts, feelings, and intention when ascribing motive for an action, while at the same time ascribing motive to others based upon situational variables. Pronin (2002) demonstrated the impact the fundamental error of attribution has on self vs. social perception that was transcendent of simple preservation and enhancement of self-concept; in other words, more than simply an above-average effect. The speculative relationship that may be implied to exist is that an individual may feel that their performance, ability, talent, or traits are above-average because they are aware of "extenuating circumstances" in their case, as opposed to others' cases—namely, their own thoughts, feelings, and intentions,

which serve as an excuse and buffer from the reality of their performance when compared with others for whom such extenuating circumstances are not as readily perceived as existing.

The actual existence, as well as the utilization of, the above-average effect is an understandable event when considered from the perspective of preserving and protecting the self-esteem and/or self-concept of the individual doing the speculating. This particularly comes into play with many "framings" of statistical information, where the cold, hard facts of an issue may be somewhat less than agreeable with our ideas of individuality and "uniqueness". After all, as the joke goes, it's somewhat disconcerting to consider that out of any given class of graduating medical students, fifty percent are graduating in the *bottom* half of their class. In many ways, the above-average effect bears close resemblance to aspects of Elkind's (1967) construct of *adolescent egocentrism*, consisting of two parts: the *personal fable* and *imaginary audience*.

The personal fable is a system or pattern of beliefs about the self that is distorted and/or embellished; hallmarks of the personal fable include consideration of oneself as unique, special, and participant to immunity from disaster (Elkind, 1967; Vartanian, 2000; Vartanian, 2001). The idea of a personal fable in adolescence has explanatory power for such events as adolescent risk-taking (feelings of invulnerability), alienation (feelings of uniqueness), loneliness (feelings of uniqueness and omnipotence), among other prototypically "adolescent" emotional states, as well as the apparent impenetrability of the adolescent population's attitudes towards personal risk (e.g., impulsive driving, safer sex, smoking, drug and alcohol consumption, etc...) (Greene, Rubin and Hale, 1996; Greene, Krcmar, and Walters, 2000; Greene, Krcmar, and Rubin, 2002; Frankenberger, 2004; Vartanian, 2004). The *imaginary audience* is a state of self-focused

thought (Vartanian 2004) whose origins lie in the adolescent's initial realization that (hearkening back to Piagetian stages), just as the adolescent has thoughts, others have thoughts—however, in accordance with the ideas of adolescent egocentrism, it is assumed that these thoughts that belong to others center on oneself (Elkind, 1967; Vartanian, 2000; Vartanian, 2001; Vartanian, 2004), to the point of development of an elaborate autobiographical narrative, and preoccupation with that narrative. The individual assumes that all others have a specific and abiding interest in them, their motivation(s), intentions, and actions. Because adolescents expect that others are attending to and evaluating their every action, by engaging in this belief, in this way these adolescents have created an imaginary audience to which they are in a constant state of reaction (Elkind, 1967; Vartanian, 2001).

Elkind's conceptualisation of adolescent egocentrism, although understudied (Frankenberger, 2000), has received general support with the exception of an avenue of revisions relating specifically to the attribution of adolescent egocentrism to a "shortcoming in personal understanding" (Lapsley and Murphy, 1985; Lapsley, 1985) based upon the difference between the point at which self-other differentiation and Elkind's egocentrism occurs in terms of Piagetian development (Lapsley and Murphy, 1985); commonly, this criticism seeks to reorient adolescent egocentrism away from a Piagetian base towards that of Blos (Lapsley and Murphy, 1985; Lapsley, 1985, Vartanian, 2004). This criticism somewhat foreshadows more recent empirical evidence supporting the likelihood of the whole of what Elkind termed adolescent egocentrism—both imaginary audience and personal fable—in fact occurs far into adulthood, though to a somewhat lesser extent (Frankenberger, 2000). Regardless of the theoretical foundation of Elkind's work, the result is the same; although there is dispute over the mechanics,

there is consistency in the acknowledgement of the construct itself (Vartanian, 2004). The impact of this evidence is that there is legitimization, albeit conceptual, for the possible relationship between some degree of a post-adolescent personal fable, with its concomitant feelings of uniqueness and invulnerability, and the occurrence of an above-average effect; the two may be a somewhat inseparable pair or related as cause and effect, if not actually one and the same phenomenon. However, not considering the relationship between the terms, it is well-established that the majority of individuals in this culture pass through such a stage to some degree, and remain in that stage for at least a brief period of time, while evidence indicates that some may never fully exit such a stage. It is an intuitive assumption worthy of further investigation that exposure to such thinking impacts other interpretations throughout the lifespan, such as the possibility that something like the Fundamental Attribution Error and the actor-observer bias (the attribution of one's own actions to external or situational elements, while attributing others' actions to internal characteristics) is a manifestation or permutation of adolescent egocentrism carried over into adulthood.

With this in mind, seems a inaccurate to continue to think of such a pairing—personal fable and imaginary audience—as *adolescent* egocentrism, considering the evidence of the extension of adolescent egocentrism well past adolescence itself. Regardless, assuming the connection between such a fable-based perspective with audience-assumptive orientation and an above-average effect, their occurrence outside of adolescence, where a less-labile sense of self is the norm, all but necessitates the existence of a defense mechanism by which this sense of self is protected against the slings and arrows of outrageous reality. The adult reasoner requires a method of reconciling events that do not concur with their perspectives—their lifestyle, values,

beliefs,…, up to and including their sense of identity itself. Such efforts are aimed at reducing the effects of disparate opinions (and events) as well as the cognitive dissonance arising from the solipsistic persona's interaction with these opinions and events. It has been shown that individuals' attributions (situational vs. dispositional) in themselves and others vary according to whether the information confirms or contradicts prior self-conceptions (Kulik, Sledge and Mahler, 1986). And, as such, an adult reasoner's need to preserve the integrity of their initial classification(s) of a situation increases as the situation more closely approaches addressing issues specifically about themselves as individuals; their inclination to preserve and protect their self-esteem increases as the threat to self-concept becomes more imminent. This type of "agenda-driven" analysis is commonly referred to as *motivated reasoning* (Kunda, 1990; Gilovich, 1991; Dawson, Gilovich and Regan, 2002; Chambers and Windschitl, 2004).

Motivated reasoning, it appears, may invoke a different approach to achieve a conclusion depending upon the type of proposition being assessed; specifically, individuals alter their initial question, their subsequent methods for analysis, and their standards of proof. When presented with a proposition the individual *desires* to be true, as Dawson, Gilovich, and Regan (2002) summarize, an individual utilizing motivated reasoning frames the proposition to evaluate the question of "*Can* I believe this?"; alternately, when presented with a proposition that the individual does not desire to be true, the individual is more likely to structure the question being asked as, "*Must* I believe this?" Each question implicitly contains a differing level of acceptable heuristic proof in the sense that the questions themselves contain an obvious bias, the first—*Can* I believe this?—oriented toward confirmation, and the second—*Must* I believe this—oriented toward disproving the proposition.

Beyond the initial motivation in reasoning, these biases in reasoning are themselves heuristics, even when asking oneself, "*Must* I believe this?" Although it may at first glance appear that this is a disconfirmatory approach and therefore is the more empirical of the two, in actuality the orientation is directed toward solicitation of evidence to the contrary of the proposition, as opposed to falsifiability in the empirical sense. The difference being that, as with most heuristics, the ability of the proposition to be disproven is not exhaustively examined; the fact that a proposition may be globally accurate but locally incorrect (as the old adage says, "it is the exception that proves the rule") is not included within the repertoire of the heuristic itself, particularly when the individual *chooses* to discontinue testing of the proposition at the first (or first few) occurrences of "proof" to the contrary of that unwelcome proposition. It has been demonstrated that in this type of reasoning, the status of a proposition as being "unproven" is equated with that proposition being "false" (Micelli, 1998), which is the desired state of the proposition, and thereby becomes the goal of the individual's search to demonstrate that they are *not* compelled to believe the undesirable proposition.

A logical explanation is that the individual interprets the belief that is resultant from such an undesirable proposition as a consequence that is derived from a specific premise—the proposition. To portray the results of such a proposition as "unproven" (and therefore "false"), the individual may attempt to deny the premise itself, adjust to allow for alternate consequence(s), attempt to identify alternative propositions (premises), or even reject the implicative relationship itself (Miceli, 1998). For example, if a tyrannical manager were asked to identify how much like himself the statement "I am an unreasonable manager" is, this

individual, seeking evidence such that they are not compelled to believe this proposition to be true, may be more likely to find any evidence to the contrary (e.g., not terminating an employee for being fifteen minutes late, and instead only docking them two hours' pay) and consider the proposition to then be "unproven". To quote Dawson, Gilovich, and Regan (2002): some supportive evidence can be found for all but the most outlandish propositions. It is notable that this is particularly true for anecdotal evidence, which often does not lend itself easily or well to rigorous empirical analysis, but which is the primary constituent of a majority of our biographical information—the very information which is reviewed in deciding the truth of a particular proposition relating to performance, ability, talent, or trait.

In asking, *"Can* I believe this?" the individual engages in a stylistically similar but slightly different type of biased reasoning: *confirmation bias*.

Confirmation bias has been defined as "the seeking or interpreting of evidence in ways that are partial to existing beliefs, expectations, or a hypothesis in hand" (Nickerson, 1998). In motivated reasoning that manifests itself in confirmation bias, the individual embarks upon a quest to prove a proposition true with an inclination to disregard opposing evidence. In the case of confirmation bias, the exception is never allowed the opportunity to prove the rule, because the exceptions are simply not attended to. Nickerson (1998) aptly draws a contrasting parallel to the roles of a defense attorney and a prosecutor. Each builds their own case with an end in mind; the defense attorney's intent is to construct a viable case for their client, while a prosecuting attorney looks at the same evidence and attempts to construct a viable case *against* that same client. Neither one is expected to engage in an "unbiased weighing of all the evidence at hand"

(Nickerson, 1998). For this reason, as Nickerson (1998) details, this is not confirmation bias; confirmation bias is a "less explicit, less consciously one-sided case-building process [that] refers usually to unwitting selectivity in the use of evidence and unwitting molding of facts to fit hypotheses or beliefs". However, the result may be the same; the individual, albeit unknowingly, constructs a case that supports what they believe without unbiasedly weighing all of the evidence at hand, and then uses that case to support their beliefs and further convince themselves of the correctness of those beliefs. It has been demonstrated that, after being asked whether one would behave in a friendly or unfriendly manner in a particular situation, being then asked to examine reasons why one would behave in that manner resulted in a less-accurate rate of prediction of one's own behavior as well as an overconfidence in the accuracy of one's prediction (Wilson and LaFleur, 1995). This is shown to be the effects of the utilization of confirmation bias at work; in seeking to explain why a particular self-generated prediction would be true, an individual is likely to focus on exactly that—*why the prediction is true*. And, in turn, the undue emphasis on why something might be true—asking "*Can* I believe this?"—cements in the individual's mind that the prediction in fact, *is* true, resulting in overconfidence in one's initial self-generated prediction when combined with the gathered "evidence" supporting the veracity of that prediction (Gilovich, 1991; Wilson and LaFleur, 1995; Nickerson, 1998; Slugoski and Wilson, 1998; Kruger and Dunning, 1999; Dawson, Gilovich and Regan, 2002; Brownstein, 2003; Koriat and Bjork, 2005).

For this reason, the above-average effect is most often attributed to a specific type of motivated reasoning (Alicke, 1985; Gilovich, 1991; Dawson, Gilovich and Regan, 2002; Chambers and Windschitl, 2004); a biased tack of reasoning subsumed under the umbrella of social

comparative judgements that is designed to preserve or protect the self-concept, that may employ varying standards of proof dependent upon the content and context of the proposition, and has been demonstrated to most likely involve an inclination towards confirmation of a belief. In this way, the mechanism by which an individual comes to mis-anchor their estimates of themselves, and then exhibit overconfidence in that estimate is inclusive, with the exception of the question of why, once an individual's initial prediction of behavior or ability is anchored at an above-average level, that estimate is immune to reassessment even after performance; this leads to the issue of *metacognition*.

Metacognition is informally considered to be one's thinking about one's thinking; as circular and possibly uninformative as this explanation is, it is also an accurate explanation. Definitionally, it is agreed that metacognition is "the knowledge and control one has over one's thinking and learning activities" (Swanson, 1990, p. 307), or "the ability to reflect on our own thoughts and knowledge" (Klin, Guzmán, and Levine, 1997, p. 1378). Individuals engage in metacognition when they review, mediate, evaluate, or revise their own thinking, based upon internal controls, or outside feedback (Kruger and Dunning, 1999). It has also been demonstrated that an additional aspect of metacognition allows the individual to examine and assess the contents of memory without actually recalling the information in full; time to access the available knowledge (answering whether or not something is known to the individual) differs from the amount of time necessary to access the full memory (Reder and Ritter, 1992). Many forms of metacognitive judgement have been shown to occur automatically, before the retrieval of the actual knowledge itself (Klin, Guzmán, and Levine, 1997). This type of metacognitive thinking can be seen as a critiquing of the retrieval process.

Initially, speculation on the nature of metacognition (prior even, to the term "metacognition") raised the question of how the same brain could be both observer and observed; this apparent paradox is commonly known as *Comte's Paradox* (Nelson, 1996), and originated from observations on the nature of introspection. Comte explained that "[…t]he thinker cannot divide himself into two, of whom one reasons whilst the other observes him reason. The organ observed and the organ observing being, in this case, identical, how could such an observation take place?" (Comte, ctd. James, 1890, qtd. Nelson, 1996, p. 103). Wundt enhanced the accessibility of the paradox somewhat by posing the analogy of "a baron who was trying to pull himself out of a bog by his own pigtail" (Nelson, 1996). Fundamentally, Comte's Paradox asks how the brain can think about something while at the same time thinking about the fact that it is thinking about something. A resolution to this question of the mind's ability to have not only a dual nature/function, but a self-referencing one, while remaining a single entity was resolved with the conceptualization of the *meta* level (differentiated from the *object* level), as developed by the philosopher Alfred Tarski as a resolution (one amongst several) of Epimenides' Paradox (Nelson, 1996). The fundamental idea behind Tarski's proposal of a meta level is that it is "separable from the object-level it refers to" (Nelson, 1996); in this way, as Nelson explains, *meta-whatever* means "whatever about whatever": Metamemory is memory about memory (e.g., "when I was young, my memory was so much more clear than it is now"), and metacognition is cognition about cognition (e.g., "I know that I know who the twenty-third President is; come on, brain…think!"), and so forth. Application of Tarski's meta-level solution to Comte's Paradox divides into two potentially parallel processes (object- and meta- level) what Comte saw as a singular process (Nelson, 1996).

Metacognition plays a role in an individual's recognition that they possess a (potentially) retrievable instance of knowledge, even if the individual is more readily able to "know that they know" than to actually recall, state, and utilize what they know. Such an event has been called "feeling-of-knowing" (Reder and Ritter, 1992; Nelson, 1996), and is a relative of "judgements of learning" (Koriat and Bjork, 2005); though the two terms are not equivalent; judgement-of-learning refers to an individual's estimation of the likelihood of recalling previously-studied items, while feeling-of-knowing refers to an individual's likelihood of recognizing non-recalled items (Souchay, Isingrini, Clarys, Taconnat, and Eustache, 2004). *Illusions (Feelings) of Familiarity* have also been studied (Whittlesea, 1993) and described as having much the same characteristics as metacognition in this respect, anticipating the "fluency" of processing, and attending to aspects of meaning, pleasantness, duration, and recency (Whittlesea, 1993). From this perspective, it is not a broad leap to conclude that Whittlesea is in fact describing metacognition. It is not that metacognition itself knows, but without the acknowledgement *by* metacognition—the confirmation of having been learnt, of being "familiar"—there is no visceral validation of "knowing". In this way, it is the metacognitive assertion of knowing that *feels* like knowing more than, perhaps, actual possession, recall, and manipulation of the knowledge. The question of how much (if any) of a role metacognition plays in such phenomena as "tip of the tongue", déjà vu, or similar occurrences—where the fact that something is known (whether true or not) is believed, but the information itself is difficult to retrieve, or irretrievable—or the converse, a disorder (e.g., Capgras syndrome) which may call into play issues of a defect in the visceral acknowledgement of familiarity perhaps by metacognition—is an interesting consideration that merits further inquiry.

It has been empirically demonstrated that individuals that exhibit less skill at a task relative to their peers tend to overestimate their own performance relative to their peers (Kruger and Dunning, 1999, Krueger and Mueller, 2002); in short, less-competent individuals feel that they perform more successfully than others in domains with which they are unfamiliar. Ironically, individuals with greater demonstrated skill in a particular domain tend to underestimate the difference between their performance and the performance of lesser-skilled others (Kruger and Dunning, 1999, Krueger and Mueller, 2002). Kruger and Dunning (1999; 2002) demonstrate that the unskilled have a "dual burden"; in addition to lacking skill at a given task, this lack of skill deprives them of the metacognition to benefit from feedback and realize that they are not skilled in performing. For this reason, lesser-skilled individuals will be more likely to misidentify their level of skill, as well as exhibit a metacognitive deficiency with respect to being aware that they are lesser-skilled (Kruger and Dunning, 1999; 2002).

In their 1999 study, Kruger and Dunning began with four predictions:

- **Prediction I:** Incompetent individuals, compared with their more competent peers, will dramatically overestimate their ability and performance relative to objective criteria
- **Prediction II:** Incompetent individuals will suffer from deficient metacognitive skills, in that they will be less able than their more competent peers to recognize competence when they see it--be it their own, or anyone else's
- **Prediction III:** Incompetent individuals will be less able than their more competent peers to gain insight into their true level of performance by means of social comparison

information. In particular, because of their difficulty recognizing competence in others, incompetent individuals will be unable to use information about the choices and performances of others to form more accurate impressions of their own ability

- **Prediction IV:** The incompetent can gain insight about their shortcomings, but this comes (paradoxically) by making them more competent, thus providing them the metacognitive skills necessary to be able to realize that they have performed poorly. (Kruger and Dunning, 1999).

These predictions were tested across four studies; in Study 1, participants were presented with a series of jokes that had been previously rated by participant matter experts. The participants were asked to rate the jokes on the same eleven-point scale that was used by the expert raters, and then were asked to rate their "ability to recognize what's funny" relative to their peers in a 0 – 99 percentile ranking (Kruger and Dunning, 1999).

In Study 2, participants completed twenty items taken from a practice LSAT assessing logical reasoning. They then were asked to rate their "general logical reasoning ability" in comparison to their peers, as well as how they felt they scored in comparison to those peers. Both of the latter rankings were in a percentile format. Then participants were asked to estimate how many of the twenty practice LSAT questions they felt they had gotten correct (Kruger and Dunning, 1999).

Study 3 had two separate phases; in Phase 1, participants completed twenty questions relating to English grammar that were taken from a nationally-used teacher preparation guide. Afterward,

participants then rated their "ability to identify grammatically correct standard English" in comparison to their peers, as well as how they felt they had just scored in comparison to those peers; both of these ratings were percentile ratings. Finally, participants were asked to estimate how many of the twenty grammar questions they felt they had answered correctly. In Phase 2 of Study 3, the bottom- and top-quartile performers from Phase 1 were asked to return several weeks later, given five of the tests from Phase 1 to grade, and asked to evaluate the competence of the peer whose test they were grading. After grading their peers' tests, participants were shown their test from Phase 1, and asked to re-evaluate their ability and performance, as well as the number of test questions they felt they had answered correctly (Kruger and Dunning, 1999).

In Study 4, participants were given a Wason-based test of logical reasoning and asked to assess their performance similarly to studies 1 – 3. Following this task, half of the participants were given "a short logical-reasoning training packet" that described "techniques for testing the veracity of logical syllogisms such as the Wason selection task" (Kruger and Dunning, 1999, p. 1128). Following this training (or filler task), all participants were asked to indicate specifically which items on the test they had just taken were answered correctly or incorrectly, as well as rate their performance relative to their peers once more (Kruger and Dunning, 1999).

In Study 1, incompetent participants overestimated their ability relative to their peers by 46 percentiles (actual performance 12^{th} percentile; estimated performance 58^{th} percentile). Participants scoring in other percentiles did not demonstrate equivalent miscalibration, and top-quartile performers as a group actually underestimated their performance relative to their peers. Study 2 essentially replicated the findings of Study 1 in the degree of miscalibration; the

incompetent greatly overestimated their ability, and the more competent tended to underestimate theirs. Phase 1 of Study 3 followed the same trend; the participants in the bottom quartile scored on average in the 10th percentile, yet estimated themselves to be in the 67th percentile with regard to their grammatical ability, and estimated their performance to be in the 61st percentile. As with Studies 1 and 2, top-quartile performers underestimated themselves; although performing in the 89th percentile, these participants ranked themselves in the 72nd percentile. Phase 2 of Study 3, which was intended to test the hypothesis that incompetent participants' skill would rob them of the ability to recognize their own—or anyone else's—competence, as well as the prediction that incompetent performers will not gain insight into their own performance as a result of witnessing another's performance. In Phase 2, after viewing others' work, bottom-quartile participants did not change their assessment of their own work (and in fact *increased* their judgement of their abilities, though that effect was non-significant). Conversely, top-quartile participants *did* increase their estimates of their own grammatical ability and percentile ranking after grading others' tests. Kruger and Dunning attributed this shift as indicative of a *false-consensus* effect; top-quartile performers were overestimating the ability of their peers until proven otherwise. This shift—away from a false-consensus effect in top-quartile performers, while bottom-quartile performers remain miscalibrated—is indicative of the role of metacognition in the evaluation of one's own performance (Kruger and Dunning, 1999). In Study 4, prior to training, the same pattern as in Studies 1 – 3 appeared; overestimation of performance by bottom-quartile performers, and underestimation of performance by top-quartile performers. Typical of the miscalibration evinced by bottom-quartile estimates, these participants scored on average in the 13th percentile on the task of logical reasoning, but ranked themselves in the 55th percentile in logical reasoning ability, and in the 53rd percentile in test performance. These same bottom-

quartile participants also estimated their raw score on average to be 5.5, when in actuality their raw score averaged at 0.3. Top-quartile performers on average performed in the 90th percentile, but estimated their logical reasoning ability to be in the 76th percentile and their test performance to be in the 79th percentile. After training in Study 4 however, participants that had previously scored in the bottom quartile became just as accurate at monitoring their performance as those who had been top-quartile scorers from the outset. Bottom-quartile performers changed their estimation of their ability from the 55th percentile to the 44th percentile, changed their performance estimate from the 51st percentile to the 32nd percentile, and changed their raw score estimate from 5.3 to 1.0. Although some miscalibration still was demonstrated, overall the trained bottom-quartile participants were more closely calibrated than before training, and untrained bottom-quartile participants demonstrated no such increase (Kruger and Dunning, 1999).

Kruger and Dunning's assessment of the dual burden borne by lesser-skilled individuals has had an alternate explanation offered that does not involve metacognition; Krueger and Mueller (2002) offer the justification for excluding metacognition based upon the observation that, as participantive and objective measures (actual and estimated percentiles) of performance will lack perfect correlation and individuals suffer from the above-average effect, both skilled and unskilled performers will commit errors in performance estimation, but lesser-skilled performers will make larger errors than skilled performers when there is an overall above-average effect (Krueger and Mueller, 2002). In short, assuming a pervasive above-average effect, the group of lesser-skilled performers' regression to the mean of overestimation of their ability will be greater than the group of skilled performers' regression to the mean of overestimation of their ability.

Kruger and Dunning (2002) replied to this assertion by pointing out that one of the tests used by Krueger and Mueller was "extremely unreliable (Spearman-Brown = .17)" and this was the test which most clearly demonstrated the above-average effect/regression effect. The other tests used by Krueger and Mueller exhibited moderate to high reliability, and these tests exhibited results in keeping with Kruger and Dunning's metacognitive explanation. Krueger and Mueller failed to find a mediating variable in metacognition, they explain, because "it is difficult for a mediator to be significantly correlated with a crucial variable, such as performance, when that variable is not measured reliably" (Kruger and Dunning, 2002, p. 190); additionally, Krueger and Mueller's measure of metacognition failed to effectively differentiate between a high correlation between participants' judgement and the actual accuracy of their judgement. More appropriate to uncovering metacognition as a mediating variable would have been an analysis of the deviational measures of metacognition as opposed to the correlational measures utilized by Krueger and Mueller (Kruger and Dunning, 2002). For these reasons, Kruger and Dunning's model is seen as the more accurate reflection of the cognitive processes interacting in self-assessment of skill.

In their 1999 study, Kruger and Dunning's bottom-quartile performers routinely under-perform, but overestimate their own performance; Kruger and Dunning hold this up as an example of the above-average effect, occurring when a general idea of the expected type of response is known. This serves to illustrate the relationship between the outward manifestation referred to as the above-average effect and the role of metacognition in determining whether an individual feels that they "know", or possess, an article of knowledge in the sense that a particular genre of information (if not the actual information itself) appears familiar, and therefore stands a

reasonable likelihood of being retrieved (or retrievable) (Reder and Ritter, 1992; Klin, Guzmán, and Levine, 1997). It would seem that having an approximation of the expected response can, under certain circumstances, masquerade as possession of the knowledge itself as our metacognitive process(es) pre-scans potential outputs for the problem-input we are receiving; the individual feels it likely that they "know" the answer based upon the identification (at the metacognitive level) of usable response options, or the potential retrievability of information relevant to the question—as before stated, *when a general idea of the expected type of response is known* (Kruger and Dunning, 1999). It has been shown (Reder, 1987; Arkes, Boehm, and Xu, 1991; Schwartz and Metcalfe, 1992; Metcalfe, Schwartz, and Joachim, 1993, qtd. Dunning, 2005) that, for certain tasks, the role of metacognition with respect to recognition of "known" participant matter may be somewhat susceptible to a "priming of the pump" by which a participant can be made to assert with a degree of certainty that the (sometimes wrong) answer to a question is in fact correct as a result of having been previously primed by information approaching the targeted (wrong) answer. Dunning (2005) cites the example of Schwartz and Metcalfe (1992), where participants displayed a greater confidence in their answer to "*Who was the first prime minister of Canada?*" if they had been exposed to the words *prime* and *minister* during a prior irrelevant task regardless of the actual correctness of their answer. The appearance of the words *prime* and *minister*, in effect, primed the pump of recognition (however incorrect) later when asked about a *prime minister*. Whittlesea (1993) similarly demonstrates the effectiveness priming has on feelings of familiarity. In this respect, the metacognitive filtering of information as "known" or "not known" seems as if it may be somewhat participant to a heuristic based at least in part upon "most recent activation", a possibility worthy of further inquiry.

Also deserving of consideration in discussing metacognition is the role that the actor-observer bias may play in our attributions, or the attributions made for us metacognitively. It has been established that a change in visual perspective—in effect, turning the actor into an observer by allowing them to take the visual perspective of an observer—results in a reorientation of attribution from (in the case of an actor) situational to dispositional (Storms, 1973). Assuming that human metacognition operates in a similarly human manner, it is easy to see how a phenomenon such as *hindsight bias* might be influenced by metacognition. An excellent (and highly realistic) example of hindsight bias is given by Harley, Carlson, and Loftus (2004, p. 960):

> Imagine the following scenario: A patient at a local hospital undergoes routine chest radiography at Time 1, and Radiologist 1 interprets the film as normal. Three years later, the patient experiences discomfort and undergoes chest radiography a second time, whereupon Radiologist 2 discovers a large tumor. Despite treatment, the patient dies. The patient's family files a medical malpractice lawsuit against Radiologist 1, claiming the tumor should have been detected at Time 1. Radiologist 2, testifying on the family's behalf, views the original Time 1 radiographs and, seeing the tumor missed by Radiologist 1, claims that it was visible at Time 1.

In the role of the actor, at the point of initial analysis, does the metacognitive process accept a different burden of proof—a situational one—than at a later time, in the role of observer? In their 2004 study, Harley, Carlson, and Loftus had participants view photographs of celebrity

faces as the resolution of the photographs was slowly changed from highly-degraded to full clarity; participants were then asked (among other conditions) to rate the point at which a peer would be able to identify (correctly) the participant in the photograph. Participants routinely overestimated the ability of a peer to recognize a familiar celebrity's photograph in a degraded condition. Instructing the participant to try to avoid such a hindsight bias did not eliminate the bias. Harley, Carlson, and Loftus present what they call a *Fluency-Misattribution Theory* to explain what is occurring; when given identity information (outcome information), targets processed more fluently succumb most readily to hindsight bias—the feeling of "I knew it all along!" This bias has been demonstrated in both a verbal (Sanna, Schwarz, and Small 2002) and visual domain (Harley, Carlson, and Loftus, 2004), and in each domain appears to follow a similar pattern. The feelings of fluency that are being misattributed originate in metacognition; after something is known, it is misrepresented to the Self to have been "known all along", and the Self accepts this determination—often with absolute surety. This touches on the same phenomenon as "feeling of knowing" (Reeder and Ritter, 1992), "judgements of learning" (Koriat and Bjork, 2005), and "illusions (or feelings) of familiarity" (Whittlesea, 1993). In this way, it seems that the perspective with which metacognition views information is susceptible to biases similar to those that affect other areas of thinking.

So it is demonstrated that metacognition is neither impartial nor infallible, and appears to operate in keeping with many of the same heuristics and biases (as well as, it could be inferred, attitudinal factors, such as optimism, pessimism, etc.,) as our own cognition. But in consideration of the everyday functioning of metacognition and its purpose as facilitator of our judgements about our own knowledge and expertise, the question of *when* the metacognitive

identification of fluency implies competence arises. According to Justin Kruger (personal communication, April 5, 2005), the "unskilled and unaware" hypothesis is applicable within domains where knowledge and competence are the same thing (e.g., recognizing humor, English grammar, and logical reasoning); such is not the case when the repertoire of behaviors that constitute competent performance differs from the realm of knowledge (or fluency). For example, an individual may desire to be an actor, but lack the talent; they simply cannot act. This individual may (and probably many do!) devote years to the study of the art of acting. They may, over time, develop the ability to discriminate and critique with startling accuracy nuances of others' performance—but they cannot replicate it. This individual may become a highly sought-after film critic, director, or even possibly acting coach—but they still remain a bad actor. In this example, the fluency necessary to *identify* a skilled performance is not the same fluency necessary to *generate* a skilled performance of one's own. Many areas have different realms of expertise that are tapped in identification of competence and generation of competence; a basketball coach does not need to know what it is to himself "slam dunk" in order to impart his expertise on the procedural aspects of such a maneuver to a player; an art critic does not need to be able to replicate the work of those whom he critiques; a music aficionado does not need to be able to generate their own works to discern what they like. In these examples, the base of knowledge that constitutes competence in identification is not the same base of knowledge that constitutes competence in generation.

In discussing where the miscalibration between competent and incompetent performance occurs then, it is established that it is at the point at which the individual's metacognition identifies a "likely" knowledge base housed in memory and conveys to the individual a visceral feeling of

fluency. The individual then feels that they are skilled, and estimates their performance upon this feeling of fluency, or familiarity. An individual knows how to speak English; the relative availability of "English grammar" as a construct represented in the mind enables the metacognitive process to communicate that "English grammar" (the construct) is "known". The individual then performs under the assumption that they are skilled—or at least as competent as most—in the realm of English grammar, the calibration of their performance in this area possibly influenced by an above-average effect, if not a full-out adolescent egocentrism. For examples that are less readily available, for which we do not have a preexisting template or estimation of the expected responsive behaviors, we are willing to admit that we don't know (Dunning, 2005). We have no problem, and little delay, in admitting that we cannot rebuild an automobile engine; we would rate our skill at heart transplantation in the lower one-half of one percent (assuming negative numbers are unavailable!) without hesitation; we will acknowledge that we cannot translate the Declaration of Independence into Mandarin Chinese—we wouldn't know where to even begin! And we acknowledge our inability because our metacognition has determined with rapidity that, if presented with such a task, it does not have a reasonable response set to offer as a solution (Dunning, 2005). For examples that are most readily available, even if as a result of priming, our metacognition will eagerly validate a feeling of "knowing". For example, we could probably paint. Perhaps not better than most, maybe about average; but give us a brush and easel, and we could probably keep up with the bulk of our peers. It is this unspoken reasoning, aided by the metacognitive identification of a probable response candidate for the presented problem, which leads the unskilled to approach tasks with confidence, but unaware all the same.

CHAPTER THREE: METHODOLOGY

Sixty-nine participants were recruited from students at the University of Central Florida. Specific recruitment for participants occurred in an undergraduate Cognitive Psychology class and three mathematics classes containing both graduate and undergraduate students, in order to ensure a wide variety of mechanical/physical/visuospatial abilities. Students recruited through a class received course credit for participation. Additional students, both graduate and undergraduate, were also allowed to volunteer as participants; these students were recruited in the Engineering department, a common room of the student union, and the Psychology department. After consenting to the study, all participants were asked for basic demographics information, as well as whether or not they had previous teaching experience (or expected to acquire teaching experience), and how pleasant they felt this experience had been (or anticipated that it would be).

Participants then filled out a short questionnaire regarding their perceived skills as an instructor for this domain and their past experiences as an instructor or tutor where they rated on a seven-point Likert scale how applicable to themselves the following statements were: Being (or imagining being) an instructor or tutor makes me nervous or uneasy; Being (or imagining being) a student or learner makes me nervous or uneasy; I have always been interested in "how things work"; Most people understand things the same way I do, that is why I am (or would be) an effective instructor or tutor; Understanding participants in school comes very easy for me; Students should follow their instructor's guidelines for problem solving, and develop their own individual style only after they have mastered the material.

These participants then completed an abbreviated form of the Bennett Mechanical Comprehension Test (BMCT) Form T (Kramer and Conoley, 1992). Following the completion of the BMCT, the participants filled out a set of questions, both open-ended and Likert-scale; participants were asked to imagine that they had just completed the BMCT as an in-class exercise, and the open-ended questions first asked the participants to speculate on how well they would expect to have performed on the BMCT were it an in-class exam for a hypothetical class; the students reported their estimated grade as a percentage (e.g., 85% being a mid-B), and it was stipulated that the students' estimates should be that which they felt they may have (hypothetically) scored with certainty to minimize the impact of overestimation. The students were also asked what percentage they would feel confident was a reasonable approximation of a hypothetical class' performance as an average, as well as the speculation of the "high" and "low" scores. The purpose of these estimations was to elicit the participants' conception of the landscape of class performance, and to place themselves in that landscape relative to their hypothetical peers. Participants were then asked to make the same approximations from the perspective of an instructor; to estimate the performance of the highest and lowest scoring students, as well as the class average, to allow for a possible shift in performance estimation.

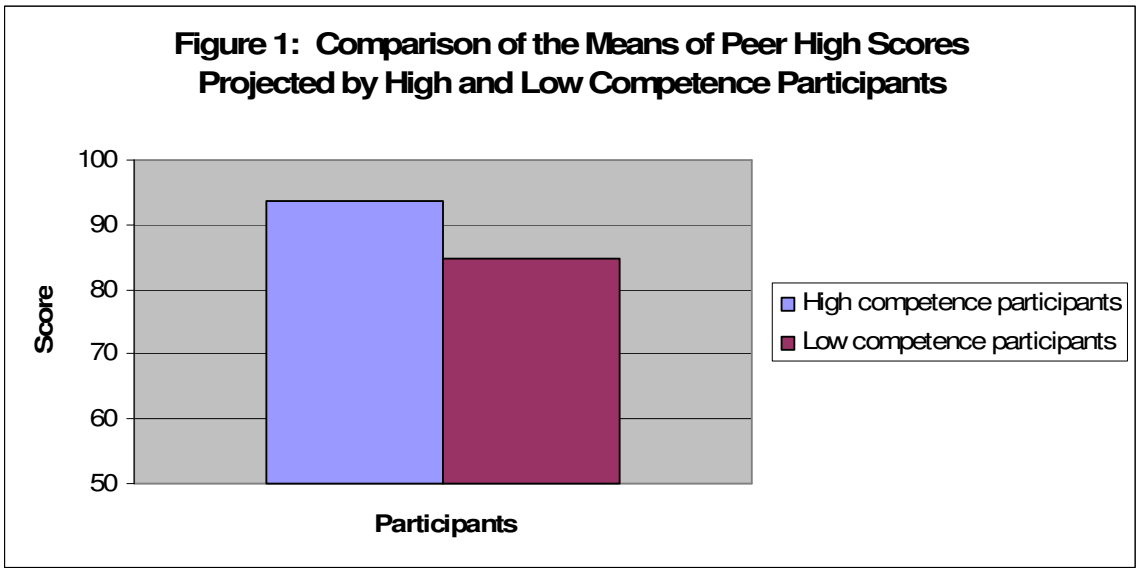
Following the approximation of the range of scores, the students were presented with an enlarged depiction of one of the test items; they were asked to explain how to arrive at the answer as if their explanation were being heard by a student that they were tutoring; these explanations were videotaped for later scoring. Participants were allowed as much time to explain as they deemed necessary. Following this mock tutoring session, participants were then asked what percentage

out of one hundred they would feel confident that the hypothetical audience to their explanation would score on a similar problem, as well as what percentage a student who did not have exposure to their explanation would score. Finally, the participants were asked what percentage they would feel to be an acceptable score on a similar problem, and then the participants rated on a Likert scale the degree of similarity between the videotaped explanation, and how the participants themselves reasoned through a problem of this type.

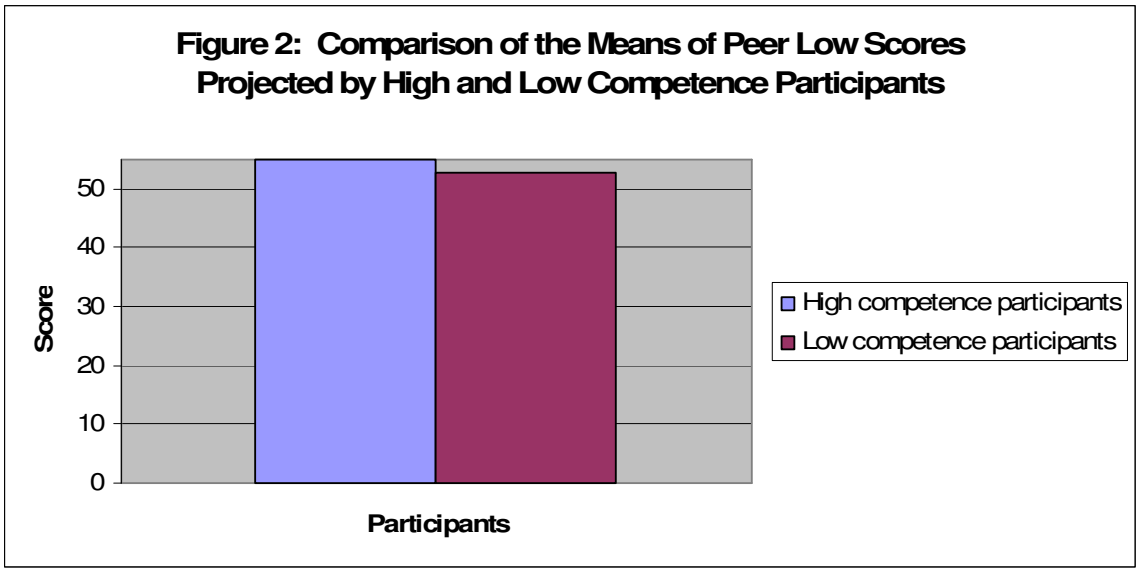
The videotapes were transcribed to facilitate scoring, and four raters received instruction on the method of rating; the raters were given a uniform working definition of biases of confirmation as well as disconfirmation, an overview of the circumstances under which the participants were taped, a transcript of the videotape, and a rating sheet on which to measure the degree to which each participant employed confirming and disconfirming strategies in their explanation. The raters were not told which answer of the two possible answers were correct, and were advised to not speculate on the "correctness" of the tutoring or the answer given, and to rate only the strategy utilized by the participants.

CHAPTER FOUR: FINDINGS

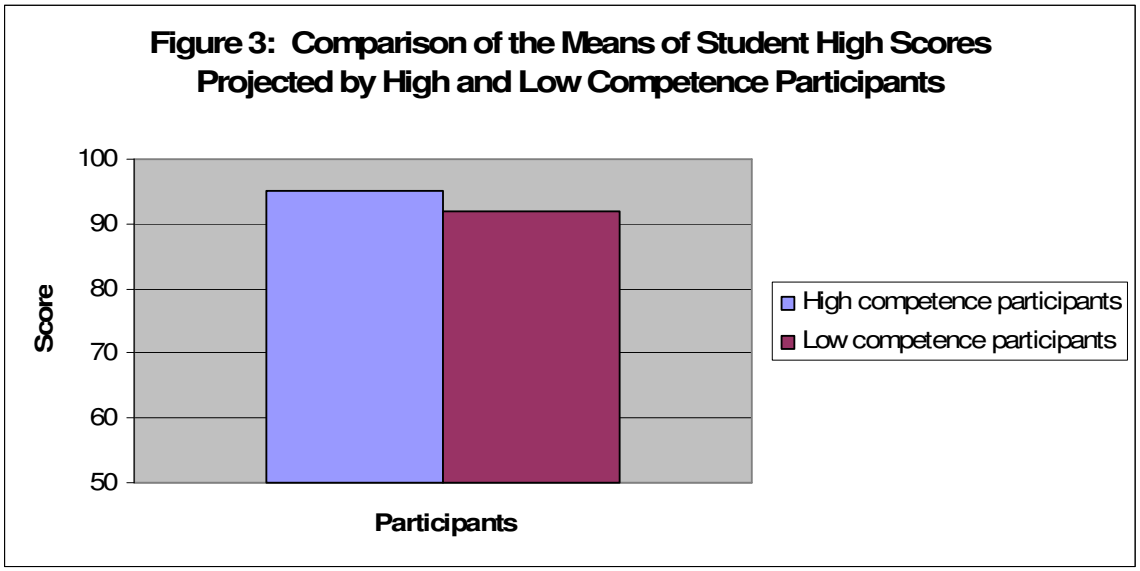
Participants' raw scores on the abbreviated Bennett were converted to percentage scores and then placed into categories of high and low competency based on a high/low median split of the percentage scores. The division of high and low competency was used as the independent variable when examining the responses to the questionnaire items. An independent samples t-test ($t(67) = 2.05$, $p = .044$) revealed that when estimating the probable high score obtained by peers taking the same exam, high competence participants ($M = 93.54$; $SD = 16.76$) differed significantly from the low competence participants ($M = 84.64$; $SD = 19.22$). As seen in Figure 1, the high competence participants tended to overestimate the probable high scores peers would achieve when taking the Bennett.



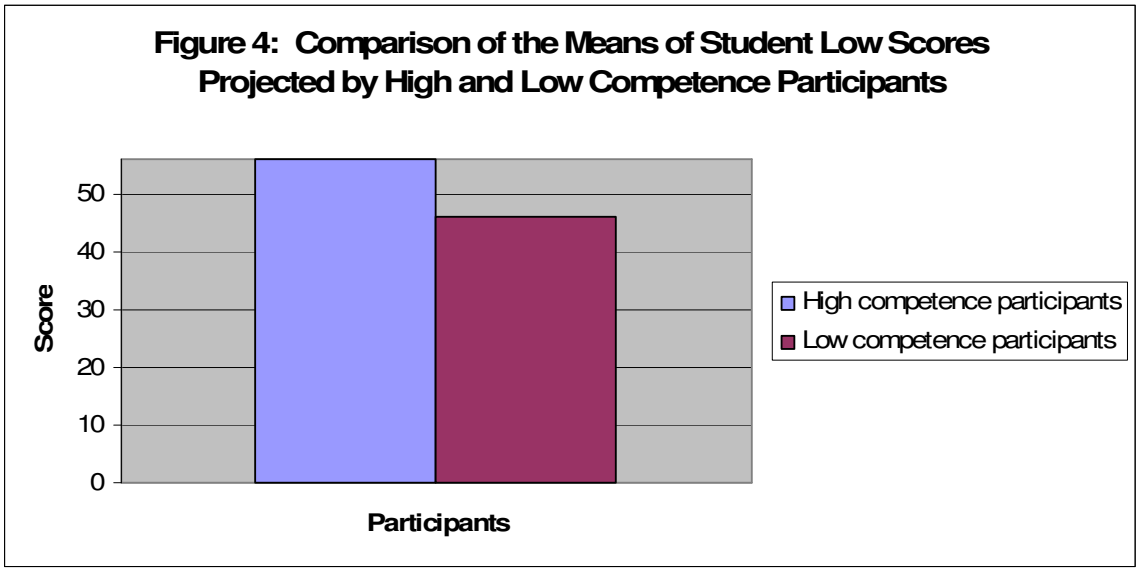
The difference was not significant, however, in estimating the low-end performance of peers. In fact, Figure 2 shows that the groups tended to be rather similar in their estimation of low-end performance.



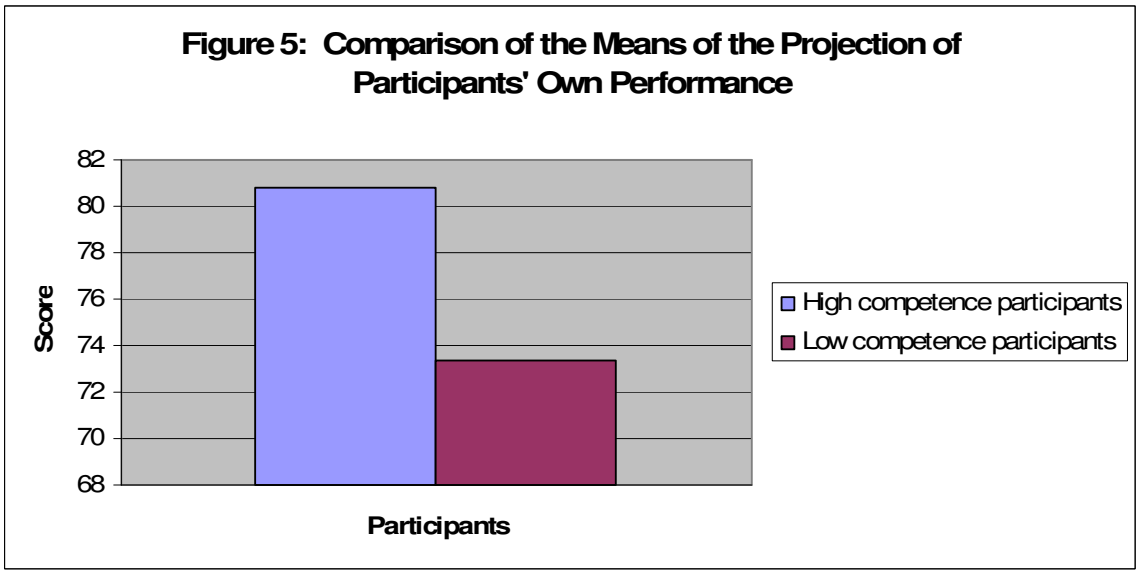
When the question was reframed so that participants were asked to estimate the performance of a hypothetical class from the perspective of an instructor, a different result emerged. The difference between the high competence group and low competence group was not significantly different when estimating the class high scores, as depicted in Figure 3.



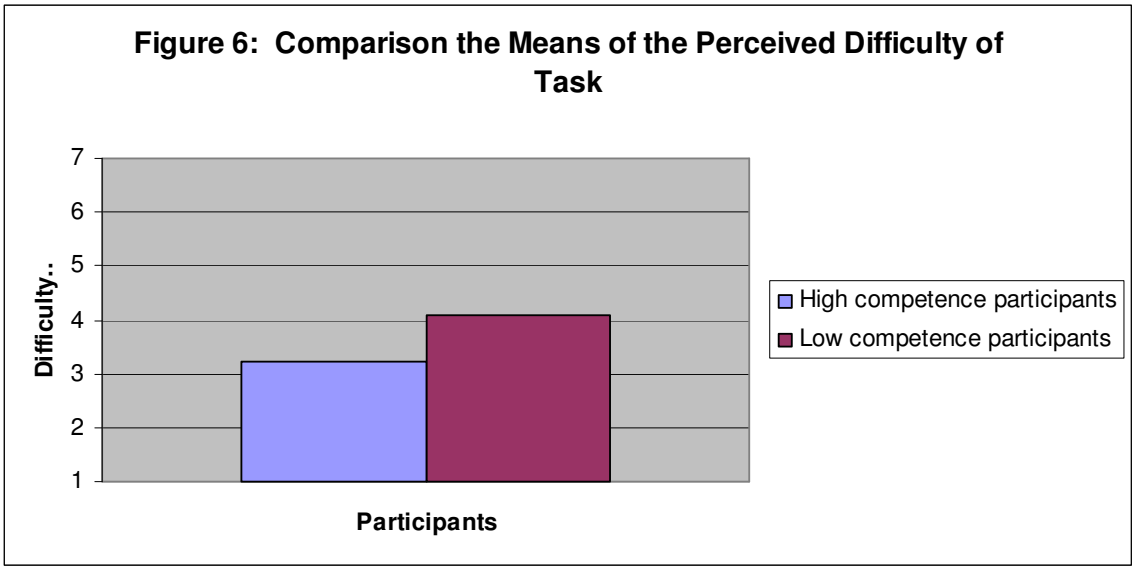
When estimating the low end performance of their hypothetical class ($t(67) = 2.73$, $p = .008$), however, participants in the high competence group ($M = 55.91$; $SD = 14.81$) differed significantly from the low competence group ($M = 45.97$; $SD = 15.46$). This tendency to overestimate the low end performance of a hypothetical class by the high competency group is depicted in Figure 4.



Participants' projections of their own scores were only marginally significant ($t(67) = 1.97$, $p = .052$) between the two groups, as depicted in Figure 5.



Participants' ratings of task difficulty also varied significantly (t(66) = 2.62, p=.011) between the two groups, where one score in the high competency group had to be deleted because of reporting error. Participants were asked to rank the difficulty of the task on a scale of 1 to 7, with 1 indicating that the task was very easy. The low competence group tended to rate the task as more difficult (M = 4.09; SD = 1.19) than the high competence group (M = 3.24; SD = 1.48), as shown in Figure 6.



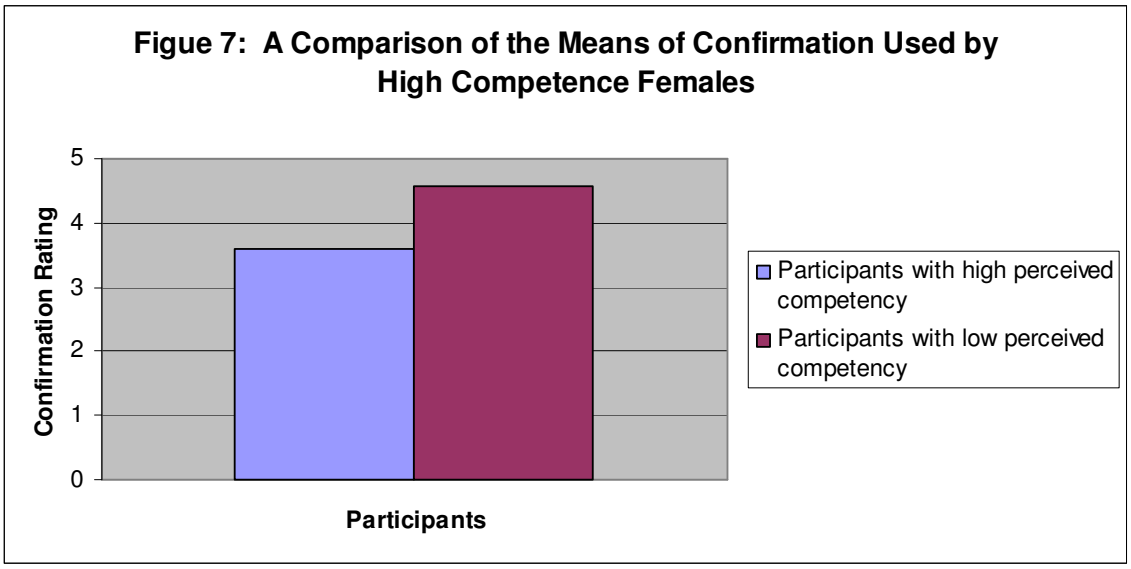
The low competence groups' underestimate of difficulty of task may result in an inadequate assessment of preparation necessary for visuospatial task performance in a real world situation.

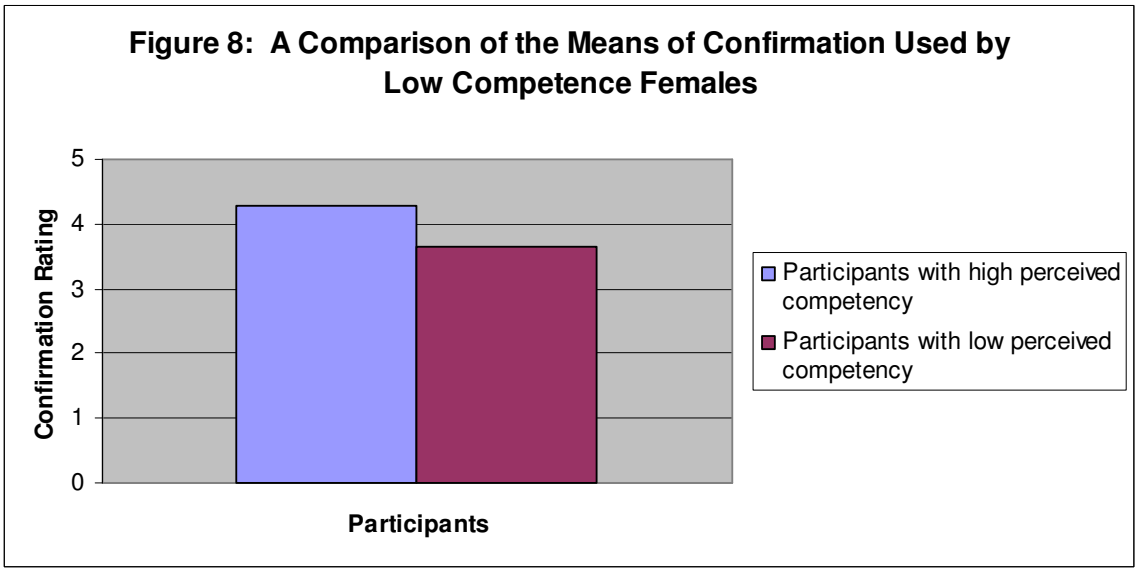
Correlations were calculated between the four raters' scores for confirmation and disconfirmation in order to establish inter-rater reliability in rating the participants' explanations of the videotaped problem. All correlations were significant at the .05 level, with correlations for

confirmation ratings ranging between .30 and .62 and correlations for disconfirmation ratings ranging between .52 and .73. Since the correlations were found to be significant, composite scores for confirmation and disconfirmation ratings were established by averaging the respective ratings among the four raters. These aggregate scores were then used as the dependent variables in two 2(Sex of Participant) x 2(Actual Competency: High or Low) x 2(Perceived Competency: Above Average or At/Below Average) Analyses of Variance (ANOVA). The Perceived Competency of the participants was established by classifying participants as high or low Perceived Competency based upon their report of their perceived score relative to their report of the average they believed their peers would achieve (high if they believed they scored above the average of their peers and low if they believed they scored below the average of their peers).

For the confirmation ratings, a significant interaction of Sex, Actual Competency, and Perceived Competency was identified ($F(1,60) = 5.64$, $p < .05$). This interaction was explored by running two separate 2(Actual Competency: High or Low) x 2(Perceived Competency: Above Average or At/Below Average) ANOVAs for males and females. Although no significant results emerged for the males, females had a significant interaction between Actual Competency and Perceived Competency ($F(1,39) = 6.25$, $p < .05$). Figure 7 shows that females with high actual competence and low perceived competence used more confirmation strategies ($M = 4.58$) than females with high actual competence and high perceived competence ($M = 3.58$). Similarly, Figure 8 shows that females with low actual competence and high perceived competence used more confirmation strategies ($M = 4.30$) that females with low actual competence and low perceived competence ($M = 3.65$). Thus, female participants who did not correctly identify the

competency level to which they belonged tended to engage in greater use of confirmation strategies than those who accurately perceived their abilities.





Significant results were not obtained for the disconfirmation ratings. A significant Pearson correlation, however, showed that a correlation existed between the greater use of disconfirmation strategies and the tendency to predict a score greater than the average of their peers ($r(67) = .24$, $p < .05$). This result suggests that the use of disconfirmation strategies may be predicted in large part by the degree of confidence in both males and females.

CHAPTER FIVE: CONCLUSION

Insufficient work has been done in the exploration of the relationship(s) between many of the issues addressed; the existing establishment of the continuation of a form of adolescent egocentrism into adulthood, and the logical inference that such a continuation may result in, or in some way affect, the appearance of an above-average effect and/or Fundamental Attribution Error that then influences or moulds metacognitive style appears to be as yet uninvestigated.

Additionally, the branches of adolescent egocentrism that appear to have a corollary in adult behavior such as the personal fable and comparative-optimism, imaginary audience and actor-observer bias (along with the possible relationship in terms of impact on and selectivity of autobiographical memory and its discriminatory or skewed recall, personal narrative, and self-concept) contains a potentially logical intertwining of constructs that may affect or relate with each other to some degree. This potential association also merits analysis.

In its ideal state, metacognition should operate as an impartial process; it is, after all, "thinking about thinking" in the sense that store-housed knowledge may be scanned prior to actual retrieval, thereby shortening the initial search time. Metacognition may also serve as a type of internal monologue regarding the direction or calibre of the cognitive procedure being conducted. However, it has been demonstrated that metacognition appears to be neither impartial nor immune to the lure of heuristic biases. Some of these impartialities and biases appear to be impacted by the individual's personal preferences, expectations, desires, and even

defense mechanisms; this apparent impact somewhat changes the perceived hierarchy of cognition/metacognition, leaving an inexplicit relationship between the two. Metacognition does not at all times enhance the individual's cognitive processes, nor does it at all times serve as a cognitive golem charged with the protection of the self-concept at the expense of perceptual accuracy. This difference in function, and the conditions and reasons for this difference, is in need of further clarification, as is the nature of metacognition itself, and errors that may be attributed to aspects (not necessarily faults) of metacognitive processing (e.g., "tip of the tongue" phenomenon, déjà vu, Capgras syndrome)

Although neither initial hypothesis was decisively supported, this study showed that, as expected, the use of a confirmation strategy in scientific reasoning is associated with a "mismatch" between perceived and actual competence; the participants who utilized a confirming strategy did demonstrate evidence of miscalibration, which may indicate deficient metacognitive skills. Surprisingly, this effect—as it was observed in this study—is stronger in females than in males. This was an unanticipated result, but one which may merit further investigation to rule out the possibility of sampling bias or, more likely, the existence of some type of stereotype threat or a related issue. Effort was made to select a task (the BMCT) that was standardized, but not overtly "unfeminine" (in a stereotypical sense), and the administrator throughout all participants was the same (female), however these measures may not have been sufficient to protect against the perception of the task as (stereotypically) "masculine". Although there were no responses or spontaneous comments that would indicate the operation of a perceived threat to "feminine" or "masculine" roles, the fact that it cannot be ruled out indicates that one possible improvement that future studies of this nature may wish to explore is the

origination of novel mechanical and visuospatial tasks that better obfuscate the skill(s) being assessed to afford improved protection against the possibility of an intrusion of stereotype threat (or a related cause). Also of issue is the possibility that females may be more (or less) likely than males to utilize a confirming strategy overall; such a possibility would also benefit from experimentation.

Speculation about possibilities of outside influence aside, in this study it is notable that gender plays a role in an interaction between Perceived Competence, and Actual Competence in predicting use of confirmation strategies. It is believed that this effect may be attributable to three causes: First, slightly fewer males participated in the study, and comparatively fewer males showed the "mismatch" in perceived and actual competence that was associated with use of confirming strategies. Second, many of the males were actually highly competent relative to the females, suggesting that this mismatch effect may only be true for participants of average to low ability, a population that was underrepresented in males. Third, it may be the case that males and females differ in the degree to which they assess their own competence and use comparison to peers to do so. The literature is replete with examples of females exhibiting declining interest in, and perceived competence at, mathematics and science after adolescence. Many of these women may have constantly looked for examples of their own competence or incompetence to support what they already believed about their abilities. Ironically, this self reflection may be associated with the use of a strategy in science that does not lead to the most accurate answers.

Although it would be natural to assume that males would also exhibit such an effect, and that this effect was not apparent because of the higher competence of the males participating, this effect is

not present for the male participants at all. Males, even though of a higher competence when taken as a whole, did not exhibit the same effect as a function of their miscalibration of their ability. It would be expected that, assuming the groups to be unaffected by gender, there would have appeared a similarly leaning tendency for the male group given that the number of male participants is adequate to ensure an approaching of a Gaussian distribution, if not precisely one in fact. Instead what is demonstrated is that, for females, misidentification of one's level of competence results in an increased usage of a confirmation-based method as a problem solving strategy and a skewed identification of group performance as well as one's point of membership in that group. It is recommended that an attempt be made to replicate this study in the future with a large enough population of males of varying ability to ensure that low-competency males do not, in fact, exhibit a strategy identical to the female group.

Although deserving of additional research, this work does validate the need for such effort in that it has shown that scientific reasoning is related to perceived competency in a visuospatial domain, and that perceived competency may interact with actual competency in predicting use of particular strategies. Based on these results, it may be said that the learning and teaching focus may be inherently different for males and females based upon their initial level of actual and perceived competence, and that females that misidentify their level of competence, whether low or high, may actually use a clustering of feedback that differs from males, as in the area of mechanical ability with respect to this study, where females appeared to tend towards using feedback cues that are social (external) rather than grading- or performance-based.

APPENDIX: TEST PACKET

Date:_____

Age: _____

Gender: M F

Major:_____

Year (circle one): Freshman Sophomore Junior Senior Postgraduate

Have you had previous experience teaching? Yes No

If yes, please rate how enjoyable this experience was for you:

1 2 3 4 5 6 7

Highly Enjoyable **Highly Unpleasant**

If no, do you expect to acquire experience teaching? Yes No

If yes, please rate how enjoyable you anticipate this experience shall be for you:

1 2 3 4 5 6 7

Highly Enjoyable **Highly Unpleasant**

Please rate how much the following statements apply to you:

Being (or imagining being) an instructor or tutor makes me nervous or uneasy.

1	2	3	4	5	6	7
Like me						Not like me

Being (or imagining being) a student or learner makes me nervous or uneasy

1	2	3	4	5	6	7
Like me						Not like me

I have always been interested in "how things work"

1	2	3	4	5	6	7
Like me						Not like me

Most people understand things the same way that I do; that is why I am (or would be) an effective instructor or tutor

1	2	3	4	5	6	7
Like me						Not like me

Understanding subjects in school comes very easy to me

1	2	3	4	5	6	7
Like me						Not like me

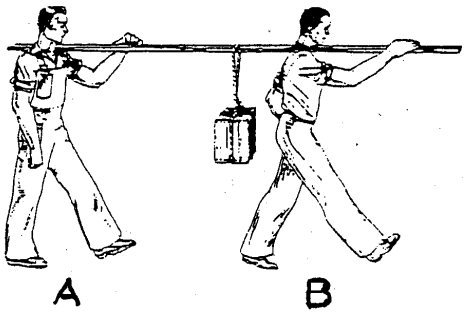
Students should follow their instructor's guidelines for problem solving, and develop their own individual style only after they have mastered the material

1	2	3	4	5	6	7
Like me						Not like me

DIRECTIONS

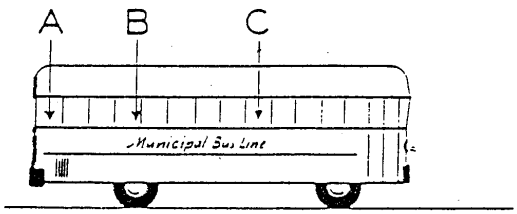
Fill in the requested information on your ANSWER SHEET.

Look at Sample X on this page. It shows two men carrying a weighted object on a plank, and it asks, "Which man carries more weight?" Because the object is closer to man "B" than to man "A," man "B" is shouldering more weight; so blacken the circle under "B" on your answer sheet. Now look at Sample Y and answer it yourself. Fill in the circle under the correct answer on your answer sheet.



X

Which man carries more weight? (If equal, mark C.)



Y

Which letter shows the seat where a passenger will get the smoothest ride?

On the following pages there are more pictures and questions. Read each question carefully, look at the picture, and fill in the circle under the best answer on the answer sheet. Make sure that your marks are heavy and black. Erase completely any answer you wish to change. Do not make any marks in this booklet.

DO NOT TURN OVER THE BOOKLET UNTIL YOU ARE TOLD TO DO SO.

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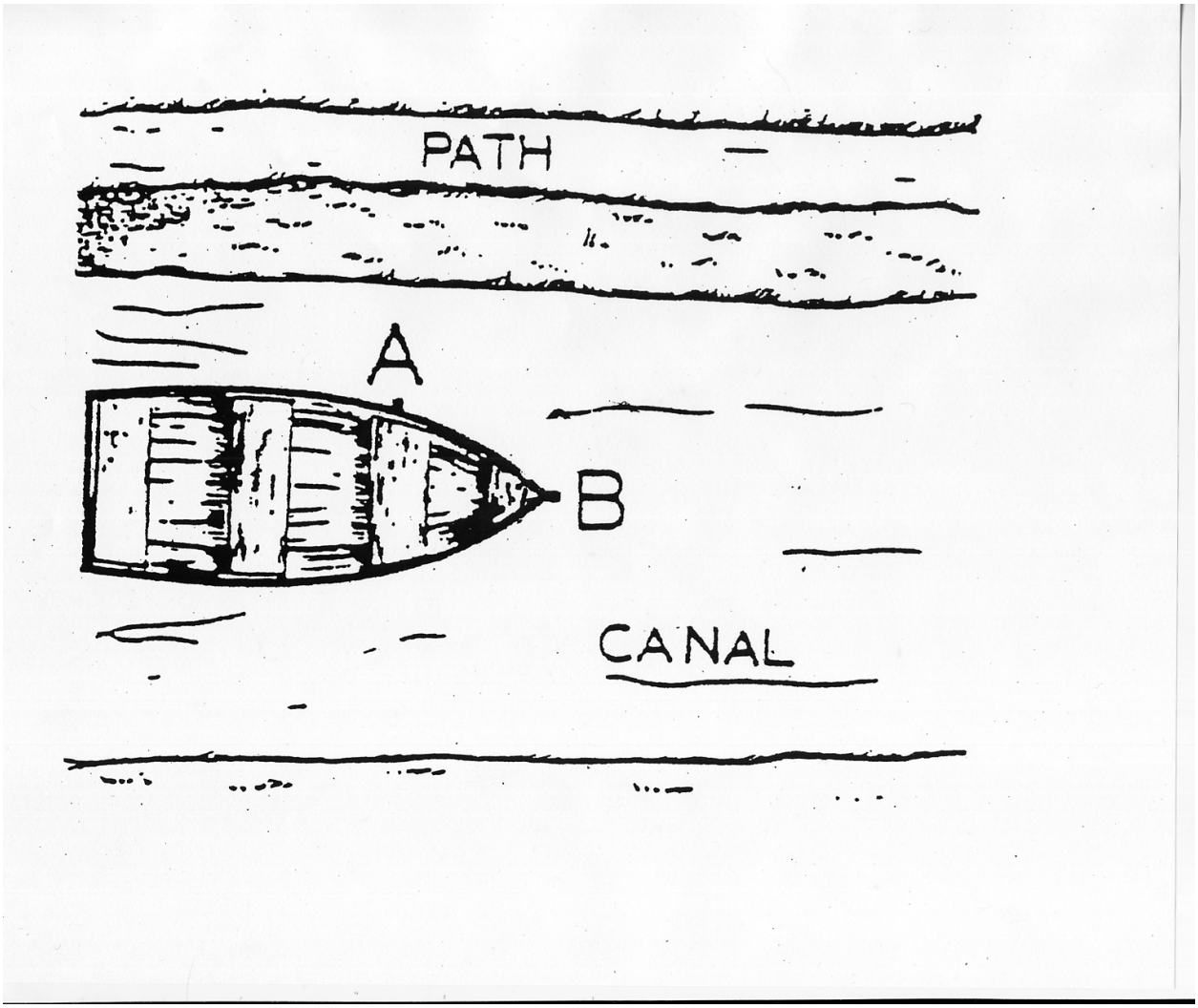
PATH
A
B
CANAL

For the next four questions, please imagine this is an in-class exercise you have just completed in one of your classes. After leaving class, you stop to think about your performance to try to estimate what grade you might expect to receive:

1. What percent out of 100 would you feel <u>confident</u> you have scored?

_____

2. What percent out of 100 would you feel <u>confident</u> is the class average for this exercise?

_____

3. What percent out of 100 would you feel <u>confident</u> is the class high and low scores for this exercise?

_____ _____
High Low

4. This exercise was: 1 2 3 4 5 6 7
Easy Hard

For the next four questions, please imagine this is an in-class exercise you have just administered as an instructor. As you collect the class' papers, you stop to think about the class' performance to try to estimate what grades you expect to see:

1. What percent out of 100 would you feel <u>confident</u> your "best" student has scored?

_____

2. What percent out of 100 would you feel <u>confident</u> your "worst" student has scored?

_____

3. What percent out of 100 would you feel <u>confident</u> is the class average for this exercise?

_____

4. This exercise was: 1 2 3 4 5 6 7
Easy Hard

For the next four questions, please imagine this is a fellow student you have just finished tutoring. After the tutoring session, you stop to think about your performance explaining how the problem "works" to try to estimate what level of understanding an average student working with you now has:

1. What percent out of 100 would you feel <u>confident</u> this student might score on a similar problem?

_____

2. What percent out of 100 would you feel a student who did not receive tutoring assistance might score on a similar problem?

_____

3. What percent out of 100 would you feel to be an acceptable score on a similar problem?

_____

4. How similar was your explanation to the way you talk yourself through a problem:

1	2	3	4	5	6	7
Very similar						Not similar at all

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